[Embankment or Fill] [Material Description] [Portland Cement Concrete]

RECLAIMED CONCRETE MATERIAL User Guideline

Granular Base

INTRODUCTION

Reclaimed concrete material (RCM) can be used as coarse and/or fine aggregate in granular base The properties of processed RCM generally exceed the minimum requirements for conventional granular aggregates Being a 100 percent crushed material, processed RCM aggregates "lock up" well in granular base applications, providing good load transfer when placed on weaker subgrade The lower compacted unit weight of RCM aggregates compared with conventional mineral aggregates results in higher yield (greater volume for the same weight), and is therefore economically attractive to contractors For large reconstruction projects, on-site processing and recycling of RCM are likely to result in economic benefits through reduced aggregate hauling costs

PERFORMANCE RECORD

RCM that has been properly processed and tested for appropriate specification compliance has been widely used and has generally demonstrated satisfactory performance in granular base applications The use of processed RCM as aggregate in base or subbase applications has been accepted by many jurisdictions Twenty states presently use RCM They include Arizona, California, Colorado, Florida, Indiana, Iowa, Louisiana, Maryland, Massachusetts, Minnesota, Missouri, Nebraska, New Jersey, New York, North Dakota, Ohio, Pennsylvania, Rhode Island, South Carolina, and Texas

Two highway agencies (Illinois and Pennsylvania) have specifications that directly address RCM use in granular base [1] A number of states are conducting or have proposed research into the use of RCM as aggregate for granular base course They include Arizona, Iowa, Louisiana, Michigan, Missouri, and Nebraska

Some of the positive features of RCM aggregates in granular base applications include the ability to stabilize wet, soft, underlying soils at early construction stages, good durability, good bearing strength, and good drainage characteristics

There is recent evidence that the use of some unsuitable or improperly processed RCM aggregate can adversely affect pavement subdrainage systems and pavement performance [2] Tufa-like (white, powdery precipitate) precipitates have been reported by a number of agencies to have clogged subdrains and blinded geotextile filters [2] The tufa precipitate appears to be Portlandite from unhydrated cement and/or calcium carbonate ($CaCO_3$), formed by the chemical reaction of atmospheric carbon dioxide with the free lime (CaO) in the RCM However, the problem is not universal, and many pavements with RCM granular base are reported to be functioning satisfactorily without any apparent tufa formation

MATERIAL PROCESSING REQUIREMENTS

ADMIN RECCRD
SW-A-003275
JUN 1999
RECEIVED
RECORDS CENTER

Crushing and Screening

Following the initial crushing of concrete rubble in a jaw crusher and removal of any steel by magnetic separation, RCM must be crushed and screened to the desired gradation using conventional aggregate processing equipment

Where the processed RCM contains some reclaimed asphalt pavement (RAP), which can occur when the RCM is derived from composite pavements, it is recommended that the RAP content in the RCM be limited to 20 percent maximum to prevent a reduction in bearing strength [3]

Storage

Where RCM is available from different sources or concrete types, it should either be blended or maintained in separate stockpiles to ensure consistent material properties

Washing

Washing of RCM aggregates is required by some agencies (Ohio, for example) to remove the dust as a measure to reduce potential tufa formation To control tufa precipitate formation, only suitable RCM that does not contain appreciable unhydrated cement or free lime should be used for granular base applications

Testing

Additional quality control testing (leachate testing) to assess the tufa precipitate potential of RCM aggregates may be necessary for granular base applications where subdrains are involved A special procedure to identify the potential for tufa formation in steel slags was developed, which should be appropriate for RCM testing [4]

ENGINEERING PROPERTIES

Some of the engineering properties of RCM that are of particular interest when RCM is used as a granular base material include gradation, absorption, specific gravity, stability, strength, durability, and drainage

Gradation RCM must be crushed and screened to satisfy AASHTO M147[5] and ASTM D2940 [6] requirements for aggregates

Absorption High absorption is particularly noticeable in crushed fine material (minus 4 75 mm (No 4 sieve)) derived from air-entrained concrete and ranges between 4 and 8 percent (compared with 2 percent or less for virgin concrete aggregates) [7]

Specific Gravity The specific gravity of RCM aggregates (ranging from 2 0 for fines to 2 5 for coarse particles) is slightly lower than that of virgin aggregates [7]

Stability RCM has high friction angle, typically in excess of 40° and consequently demonstrates good stability and little postcompaction settlement

Strength Characteristics Processed RCM, being a 100 percent crushed material, is highly angular in shape It exhibits California Bearing Ratio (CBR) values ranging from 90 to more than 140 (depending on the angularity of the virgin concrete aggregate and strength of the Portland cement matrix), which is comparable to crushed limestone aggregates [8 9]

The inclusion of asphalt-coated particles in granular base material leads to reduced bearing capacity, varying with the proportion of asphalt-coated particles Studies in Ontario, Canada, indicate that bearing strength is reduced below that expected for granular base (using natural aggregate) when the amount of blended asphalt coated particles exceeds 20 to 25 percent [8]

Durability RCM aggregates generally exhibit good durability with resistance to weathering and erosion RCM is nonplastic, and is not susceptible to frost

Drainage Characteristics RCM (mainly coarse fraction) is free draining and is more permeable than conventional granular material because of lower fines content

DESIGN CONSIDERATIONS

Processed RCM aggregates generally satisfy the requirements of AASHTO M147[5] and ASTM D2940 [6] Processed RCM is covered by conventional granular aggregate specifications in a number of jurisdictions

Standard AASHTO pavement structural design procedures can be employed for granular base containing RCM aggregates It is recommended that the appropriate structural number for RCM aggregates should be established by resilient modulus testing

CONSTRUCTION PROCEDURES

Material Handling and Storage

The same methods and equipment used to store or stockpile conventional aggregates are applicable for RCM However, additional care is required in stockpiling and handling RCM aggregates to avoid segregation of coarse and fine RCM

Placing and Compacting

The same methods and equipment used to place and compact conventional aggregate can be used to place and compact RCM

Quality Control

The same test procedures as used for conventional aggregate are appropriate for granular base applications when using RCM Standard laboratory and field tests for compacted density and field measurement of compaction are given by AASHTO test methods T191[10], T205[11], T238[12] and T239 [13]

Special Considerations

Although there do not appear to be any environmental problems associated with leachate from RCM,[14,15] some jurisdictions require that stockpiles be separated (a minimum distance) from water courses because of the alkaline nature of RCM leachate

Where RCM aggregates are used in granular base course applications in conjunction with subdrains, the following procedures are recommended to reduce the likelihood of leachate

precipitates clogging the drainage system [7]

- Wash the processed RCM aggregates to remove dust from the coarse particles
- Ensure that any geotextile fabric surrounding the drainage trenches (containing the subdrains) does not intersect the drainage path from the base course (to avoid potential plugging with fines)

UNRESOLVED ISSUES

Further investigation of the propensity for tufa formation of RCM aggregates in granular base is needed This should also include the development of standard methods to assess the suitability of RCM aggregates for base course applications where subdrains are used

REFERENCES

1 Collins, R J and S K Cielieski *Recycling and Use of Waste Materials and By-Products in Highway Construction,* National Cooperative Highway Research Program Synthesis of Highway Practice 199, Transportation Research Board, Washington, 1994

2 Gupta, J D and W A Kneller *Precipitate Potential of Highway Subbase Aggregates,* Report No FHWA/OH-94/004 prepared for the Ohio Department of Transportation, November 1993

3 Hanks, A J and E R Magni *The Use of Recovered Bituminous and Concrete Materials in Granular Base and Earth,* Ontario Ministry of Transportation Report MI-137, Downsview, Ontario, 1989

4 Gupta, J D , W A Kneller, R Tamirisa, and E Skrzypczak-Jankun "Characterization of Base and Subbase Iron and Steel Slag Aggregates Causing Deposition of Calcareous Tufa in Drains," *Transportation Research Record No 1434,* 1994

5 American Association of State Highway and Transportation Officials Standard Specification for Materials, "Aggregate and Soil-Aggregate Subbase, Base and Surface Courses," AASHTO Designation M147-70 (1980), Part I Specifications, 14th Edition,1986

6 American Society for Testing and Materials Standard Specification D2940-92, "Graded Aggregate Material for Bases and Subbases for Highways or Airports," Annual Book of ASTM Standards, Volume 4 03, West Conshohocken, Pennsylvania, 1996

7 ACPA *Concrete Paving Technology Recycling Concrete Pavement,* American Concrete Pavement Association, Illinois, 1993

8 Senior, S A S I Szoke, and C A Rogers, "Ontario's Experience with Reclaimed Materials for Use as Aggregates," Presented at the International Road Federation Conference, Calgary, Alberta, 1994

9 Petrarca, R W and V A Galdiero, "Summary of Testing of Recycled Crushed Concrete," *Transportation Research Board No 989,* pp 19-26, Washington, D C , 1984

10 American Association of State Highway and Transportation Officials Standard Method of

Test, "Density of Soil In-Place by the Sand Cone Method," AASHTO Designation T191-86, Part II Tests, 14th Edition, 1986

11 American Association of State Highway and Transportation Officials Standard Method of Test, "Density of Soil In-Place by the Rubber-Balloon Method," AASHTO Designation T205-86, Part II Tests, 14th Edition, 1986

12 American Association of State Highway and Transportation Officials Standard Method of Test, "Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)," AASHTO Designation T238-86, Part II Tests, 14th Edition, 1986

13 American Association of State Highway and Transportation Officials Standard Method of Test, "Moisture Content of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth)," AASHTO Designation T239-86, Part II Tests, 14th Edition, 1986

14 Kreitch, A J *Leachability of Asphalt and Concrete Pavements,* Heritage Research Group Report, Indianapolis, Indiana, March 1992

15 IGGA *Grinding Slurry Analysis,* International Grooving and Grinding Association, Skyland, November 1990

[Embankment or Fill] [Material Description] [Portland Cement Concrete]